Biology I

Indiana's academic standards for Biology I contain two standards, The Principles of Biology and Historical Perspectives of Biology. Ideas listed underneath each standard build the framework for a first-year Biology course.

In addition, ideas from the following four supporting themes will enable students to understand that science, mathematics, and technology are interdependent human enterprises, and that scientific knowledge and scientific thinking serve both individual and community purposes.

The Nature of Science and Technology

It is the union of science and technology that forms the scientific endeavor and that makes it so successful. Although each of these human enterprises has a character and history of its own, each is dependent on and reinforces the other. This first theme draws portraits of science and technology that emphasize their roles in the scientific endeavor and reveal some of the similarities and connections between them. In order for students to truly understand the nature of science and technology, they must model the process of scientific investigation through inquiries, fieldwork, lab work, etc. Through these experiences, students will practice designing investigations and experiments, making observations, and formulating theories based on evidence.

Scientific Thinking

There are certain thinking skills associated with science, mathematics, and technology that young people need to develop during their school years. These are mostly, but not exclusively, mathematical and logical skills that are essential tools for both formal and informal learning and for a lifetime of participation in society as a whole. Good communication is also essential in order to both receive and disseminate information and to understand others' ideas as well as have one's own ideas understood. Writing, in the form of journals, essays, lab reports, procedural summaries, etc., should be an integral component of students' experiences in Biology I.

The Mathematical World

Mathematics is essentially a process of thinking that involves building and applying abstract, logically connected networks of ideas. These ideas often arise from the need to solve problems in science, technology, and everyday life – problems ranging from how to model certain aspects of a complex scientific problem to how to balance a checkbook. Students should apply mathematics in scientific contexts and understand that mathematics is a tool used in science to help solve problems, make decisions, and understand the world around them.

Common Themes

Some important themes, such as systems, models, constancy, and change, pervade science, mathematics, and technology and appear over and over again, whether we are looking at ancient civilization, the human body, or a comet. These ideas transcend disciplinary boundaries and prove fruitful in explanation, in theory, in observation, and in design. These themes provide students with opportunities to engage in long-term and on-going laboratory and fieldwork and to understand the role of change over time in studying concepts in Biology I.

Standard 1

Principles of Biology

Students work with the concepts, principles, and theories that enable them to understand the living environment. They recognize that living organisms are made of cells or cell products that consist of the same components as all other matter, involve the same kinds of transformations of energy, and move using the same kinds of basic forces. Students investigate, through laboratories and fieldwork, how living things function and how they interact with one another and their environment.

Molecules and Cells

B.1.1 Recognize that and explain how the many cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. Understand that different parts of the genetic instructions are used in different types of cells and are influenced by the cell's environment and past history.

B.1.2 Explain that every cell is covered by a membrane that controls what can enter and leave the cell. Recognize that in all but quite primitive cells, a complex network of proteins provides organization and shape. In addition, understand that flagella and/or cilia may allow some Protista, some Monera, and some animal cells to move.

B.1.3 Know and describe that within the cell are specialized parts for the transport of materials, energy capture and release, protein building, waste disposal, information feedback, and movement. In addition to these basic cellular functions common to all cells, understand that most cells in multicellular organisms perform some special functions that others do not.

B.1.4 Understand and describe that the work of the cell is carried out by the many different types of molecules it assembles, such as proteins, lipids, carbohydrates, and nucleic acids.

B.1.5 Demonstrate that most cells function best within a narrow range of temperature and acidity. Note that extreme changes may harm cells, modifying the structure of their protein molecules and therefore, some possible functions.

B.1.6 Show that a living cell is composed mainly of a small number of chemical elements – carbon, hydrogen, nitrogen, oxygen, phosphorous, and sulfur. Recognize that carbon can join to other carbon atoms in chains and rings to form large and complex molecules.

B.1.7 Explain that complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Note that cell behavior can also be affected by molecules from other parts of the organism, such as hormones.

B.1.8 Understand and describe that all growth and development is a consequence of an increase in cell number, cell size, and/or cell products. Explain that cellular differentiation results from gene expression and/or environmental influence. Differentiate between mitosis and meiosis.

B.1.9 Recognize and describe that both living and nonliving things are composed of compounds, which are themselves made up of elements joined by energy-containing bonds, such as those in ATP.

B.1.10 Recognize and explain that macromolecules such as lipids contain high energy bonds as well.

Developmental and Organismal Biology

B.1.11 Describe that through biogenesis all organisms begin their life cycles as a single cell and that in multicellular organisms, successive generations of embryonic cells form by cell division.

B.1.12 Compare and contrast the form and function of prokaryotic and eukaryotic cells.

B.1.13 Explain that some structures in the modern eukaryotic cell developed from early prokaryotes, such as mitochondria, and in plants, chloroplasts.

B.1.14 Recognize and explain that communication and/or interaction are required between cells to coordinate their diverse activities.

B.1.15 Understand and explain that, in biological systems, structure and function must be considered together.

B.1.16 Explain how higher levels of organization result from specific complexing and interactions of smaller units and that their maintenance requires a constant input of energy as well as new material.

B.1.17 Understand that and describe how the maintenance of a relatively stable internal environment is required for the continuation of life and explain how stability is challenged by changing physical, chemical, and environmental conditions, as well as the presence of disease agents.

B.1.18 Explain that the regulatory and behavioral responses of an organism to external stimuli occur in order to maintain both short- and long-term equilibrium.

B.1.19 Recognize and describe that metabolism consists of the production, modification, transport, and exchange of materials that are required for the maintenance of life.

B.1.20 Recognize that and describe how the human immune system is designed to protect against microscopic organisms and foreign substances that enter from outside the body and against some cancer cells that arise within.

Genetics

B.1.21 Understand and explain that the information passed from parents to offspring is transmitted by means of genes which are coded in DNA molecules.

B.1.22 Understand and explain the genetic basis for Mendel's laws of segregation and independent assortment.

B.1.23 Understand that and describe how inserting, deleting, or substituting DNA segments can alter a gene. Recognize that an altered gene may be passed on to every cell that develops from it, and that the resulting features may help, harm, or have little or no effect on the offspring's success in its environment.

B.1.24 Explain that gene mutations can be caused by such things as radiation and chemicals. Understand that when they occur in sex cells, the mutations can be passed on to offspring; if they occur in other cells, they can be passed on to descendant cells only.

B.1.25 Explain that gene mutation in a cell can result in uncontrolled cell division, called cancer. Also know that exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer.

B.1.26 Demonstrate how the genetic information in DNA molecules provides instructions for assembling protein molecules and that this is virtually the same mechanism for all life forms.

B.1.27 Explain that the similarity of human DNA sequences and the resulting similarity in cell chemistry and anatomy identify human beings as a unique species, different from all others. Likewise, understand that every other species has its own characteristic DNA sequence.

B.1.28 Illustrate that the sorting and recombination of genes in sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents. Recognize that genetic variation can occur from such processes as crossing over, jumping genes, and deletion and duplication of genes.

B.1.29 Understand that and explain how the actions of genes, patterns of inheritance, and the reproduction of cells and organisms account for the continuity of life, and give examples of how inherited characteristics can be observed at molecular and whole-organism levels – in structure, chemistry, or behavior.

Evolution

B.1.30 Understand and explain that molecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched off from one another.

B.1.31 Describe how natural selection provides the following mechanism for evolution: Some variation in heritable characteristics exists within every species, and some of these characteristics give individuals an advantage over others in surviving and reproducing. Understand that the advantaged offspring, in turn, are more likely than others to survive and reproduce. Also understand that the proportion of individuals in the population that have advantageous characteristics will increase.

B.1.32 Explain how natural selection leads to organisms that are well suited for survival in particular environments, and discuss how natural selection provides scientific explanation for the history of life on Earth as depicted in the fossil record and in the similarities evident within the diversity of existing organisms.

B.1.33 Describe how life on Earth is thought to have begun as simple, one-celled organisms about 4 billion years ago. Note that during the first 2 billion years, only single-cell microorganisms existed, but once cells with nuclei developed about a billion years ago, increasingly complex multicellular organisms evolved.

B.1.34 Explain that evolution builds on what already exists, so the more variety there is, the more there can be in the future. Recognize, however, that evolution does not necessitate long-term progress in some set direction.

B.1.35 Explain that the degree of kinship between organisms or species can be estimated from the similarity of their DNA sequences, which often closely matches their classification based on anatomical similarities. Know that amino acid similarities also provide clues to this kinship.

B.1.36 Trace the relationship between environmental changes and changes in the gene pool, such as genetic drift and isolation of sub-populations.

Ecology

B.1.37 Explain that the amount of life any environment can support is limited by the available energy, water, oxygen, and minerals, and by the ability of ecosystems to recycle the residue of dead organic materials. Recognize, therefore, that human activities and technology can change the flow and reduce the fertility of the land.

B.1.38 Understand and explain the significance of the introduction of species, such as zebra mussels, into American waterways, and describe the consequent harm to native species and the environment in general.

B.1.39 Describe how ecosystems can be reasonably stable over hundreds or thousands of years. Understand that if a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually result in a system similar to the original one.

B.1.40 Understand and explain that like many complex systems, ecosystems tend to have cyclic fluctuations around a state of rough equilibrium. However, also understand that ecosystems can always change with climate changes or when one or more new species appear as a result of migration or local evolution.

B.1.41 Recognize that and describe how human beings are part of Earth's ecosystems. Note that human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.

B.1.42 Realize and explain that at times, the environmental conditions are such that plants and marine organisms grow faster than decomposers can recycle them back to the environment. Understand that layers of energy-rich organic material thus laid down have been gradually turned into great coal beds and oil pools by the pressure of the overlying earth. Further understand that by burning these fossil fuels, people are passing most of the stored energy back into the environment as heat and releasing large amounts of carbon dioxide.

B.1.43 Understand that and describe how organisms are influenced by a particular combination of living and nonliving components of the environment.

B.1.44 Describe the flow of matter, nutrients, and energy within ecosystems.

B.1.45 Recognize that and describe how the physical or chemical environment may influence the rate, extent, and nature of the way organisms develop within ecosystems.

B.1.46 Recognize and describe that a great diversity of species increases the chance that at least some living things will survive in the face of large changes in the environment.

B.1.47 Explain, with examples, that ecology studies the varieties and interactions of living things across space while evolution studies the varieties and interactions of living things across time.

Standard 2

Historical Perspectives of Biology

Students gain understanding of how the scientific enterprise operates through examples of historical events. Through the study of these events, they understand that new ideas are limited by the context in which they are conceived, are often rejected by the scientific establishment, sometimes spring from unexpected findings, and grow or transform slowly through the contributions of many different investigators.

B.2.1 Explain that prior to the studies of Charles Darwin, the most widespread belief was that all known species were created at the same time and remained unchanged throughout history. Note that some scientists at the time believed that features an individual acquired during a lifetime could be passed on to its offspring, and the species could thereby gradually change to fit an environment better.

B.2.2 Explain that Darwin argued that only biologically inherited characteristics could be passed on to offspring. Note that some of these characteristics were advantageous in surviving and reproducing. Understand that the offspring would also inherit and pass on those advantages, and over generations the aggregation of these inherited advantages would lead to a new species.

B.2.3 Describe that the quick success of Darwin's book *Origin of Species*, published in 1859, came from the clear and understandable argument it made, including the comparison of natural selection to the selective breeding of animals in wide use at the time, and from the massive array of biological and fossil evidence it assembled to support the argument.

B.2.4 Explain that after the publication of *Origin of Species*, biological evolution was supported by the rediscovery of the genetics experiments of an Austrian monk, Gregor Mendel, by the identification of genes and how they are sorted in reproduction, and by the discovery that the genetic code found in DNA is the same for almost all organisms.